Effect of barrier rib morphologies on luminance of PDP

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Abstract

Closed-cell type barrier ribs such as honeycomb, SDR, inverse SDR and waffle types were produced using capillary molding process. Phosphor layers were formed by osmosis coating process on those barrier ribs. Using the rear plate with closed-cell ribs, the luminance and its efficiency was measured. The results demonstrated a significant improvement in efficiency by combining closed-cell type ribs with a new phosphor forming technology

1. Objectives and Background

Unlike conventional CRTs or projection displays, PDP has extraordinarily slim dimensions relative to its large screen size displays[1]. However, its cost of manufacturing has to be reduced and its luminous efficiency needs to be improved[2]. Currently, barrier ribs of PDP are produced by powderblasting a thick film, which is prepared by multiple screen printing of paste containing ceramic powders[3]. The film needs 7-8 times of printing and the same number of drying steps to obtain the required thickness, approximately 200 μm[4]. The powderblasting process is low in productivity and results in over 70% materials loss during the process. In addition, the barrier ribs of high-definition and closed-cell type are difficult to fabricate with the powderblasting process.

In this study, therefore, capillary molding was used to prepare barrier ribs of closed-type cells. A soft mold prepared by photolithography method is placed on the top of the paste and the paste is infiltrated into the mold cavity by the capillary pressure developed between the mold and paste. This process does not require any external pressure for the formation of the ribs and has an advantage of one step process. In addition, the material loss during the process is negligible, making the process highly economical.

In this study, closed-cell type ribs including honeycomb, SDR, inverse SDR and waffle structures were prepared using the process. The luminance and luminance efficiency of the panels with such cells were measured. In addition, the effect of barrier rib width on the luminance and luminance efficiency were studied.

2. Experimental procedures

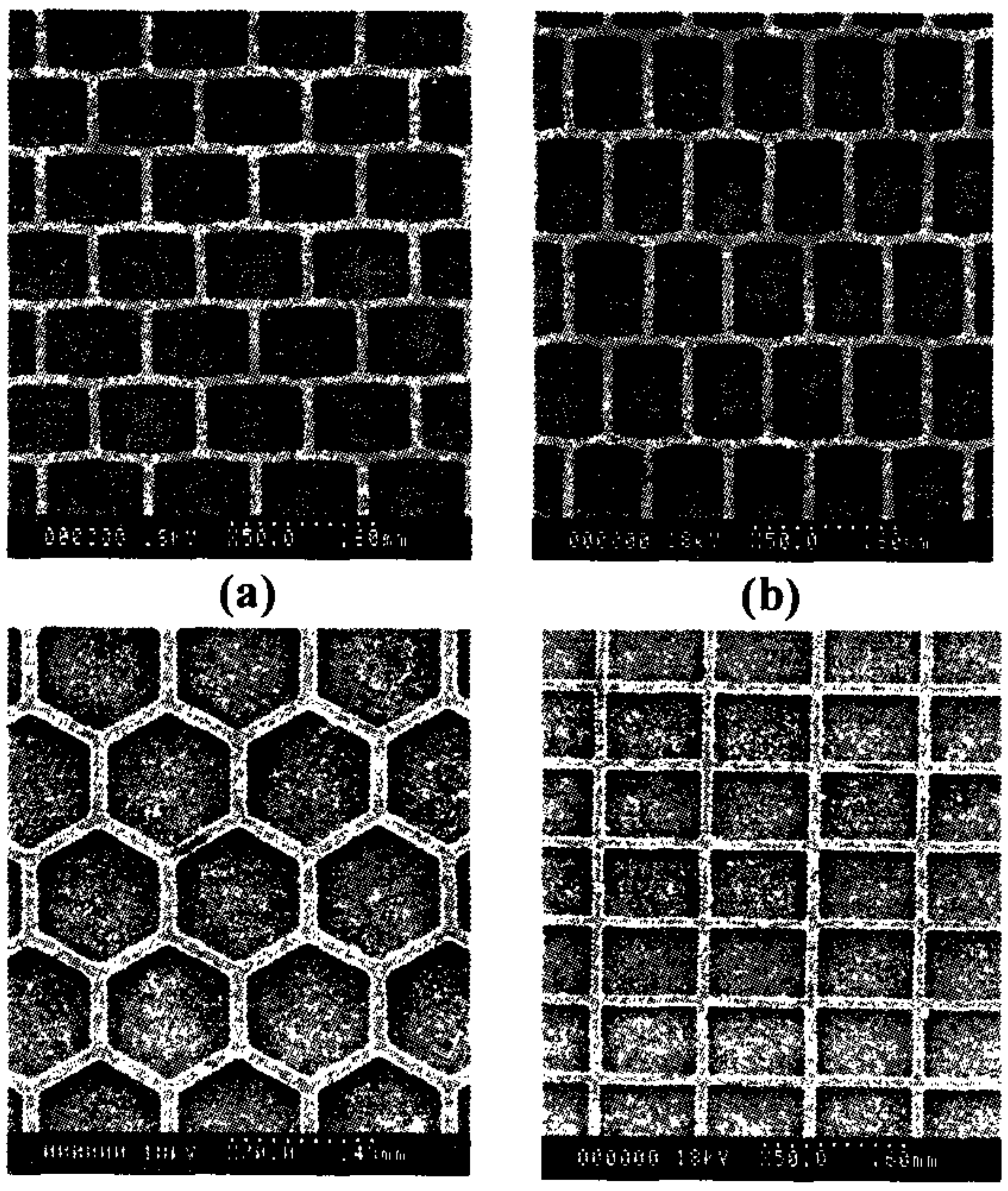
Capillary infiltration molding process using a thermo-curable paste containing ceramic powders of barrier ribs and soft mold was conducted. The infiltration of paste into mold was carried out at 70~80℃ after setting a PDMS mold on the glass substrate. After the paste molding, the substrate and mold was cured at 120°C for 1hrs in an oven and cooled to room temperature. The sample was released from the PDMS mold, and sintered at the 570℃ for 30 minutes.

3. Results and discussion

3.1. Morphologies of closed-type discharge cells

Fig.1 shows closed-cell type barrier ribs after sintering. As noted from Fig 1(a) and Fig. 1(b), SDR and inverse SDR type cells became distorted by the sintering. The distortion is mainly due to asymmetric sintering stress at the junctions where the ribs meet each other. The morphology of Fig. 1(b) is termed as inverse SDR since the regular SDR cells were rotated 90°.

The honeycomb and waffle type cells, on the other hand, the distortion was not notable. These cells are symmetric at the junctions and the sintering stress is cancelled each other at the points.



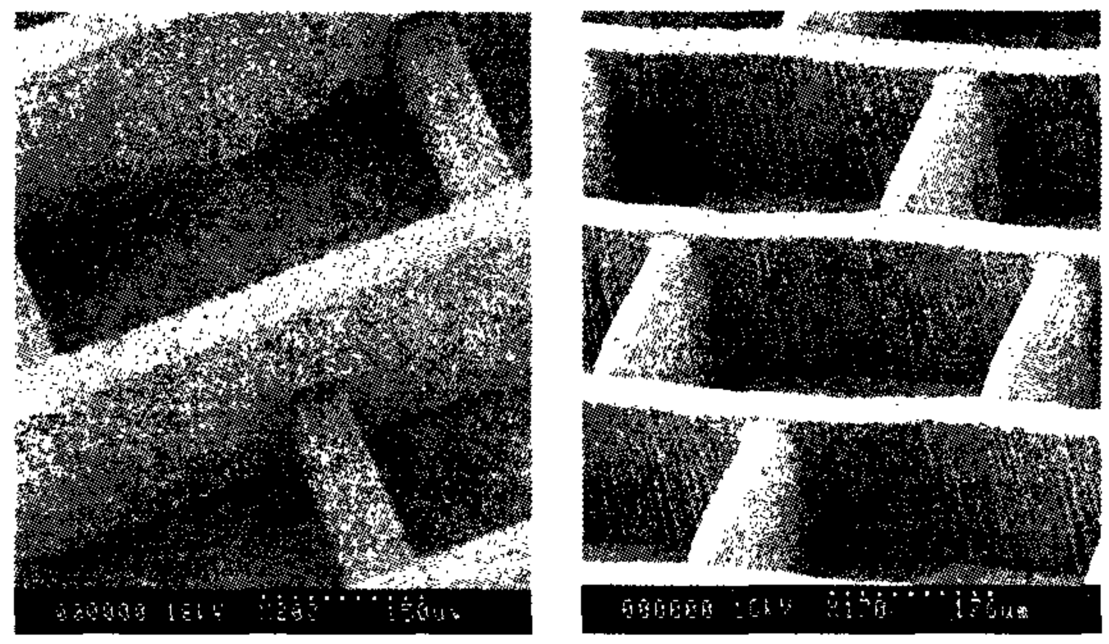
(a) (b)

(c) (d)

Fig 1. Waffle(a) and honeycomb (b) type barrier ribs via capillary infiltration method.

Fig. 2 shows sintered morphology of step-formed cells, which were designed to facilitate the evacuation processing during vacuum sealing process of PDP panel. When the height of the crossing ribs was reduced (Fig. 2(a)), the sintering distortion of the horizontal ribs was negligible as the sintering stress from the crossing ribs is reduced. When the height of the crossing ribs became similar to that of the horizontal ribs (Fig. 2(b)), the sintering distortion became similar to that of regular SDR of Fig. 1(a).

Figure 3 shows cross section of waffle type barrier ribs coated with phosphor layer. The layer was formed by osmosis coating process which utilizes the osmosis pressure developed upon evaporation of solvent from discharge cells. Unlike the conventional printing process, a phosphor layer with a very uniform thickness was formed on the sidewall of barrier ribs as well as on the surface of dielectric layer of rear plate.



(a) (b)

Figure 2. SEM micrograph of step-formed SDR.

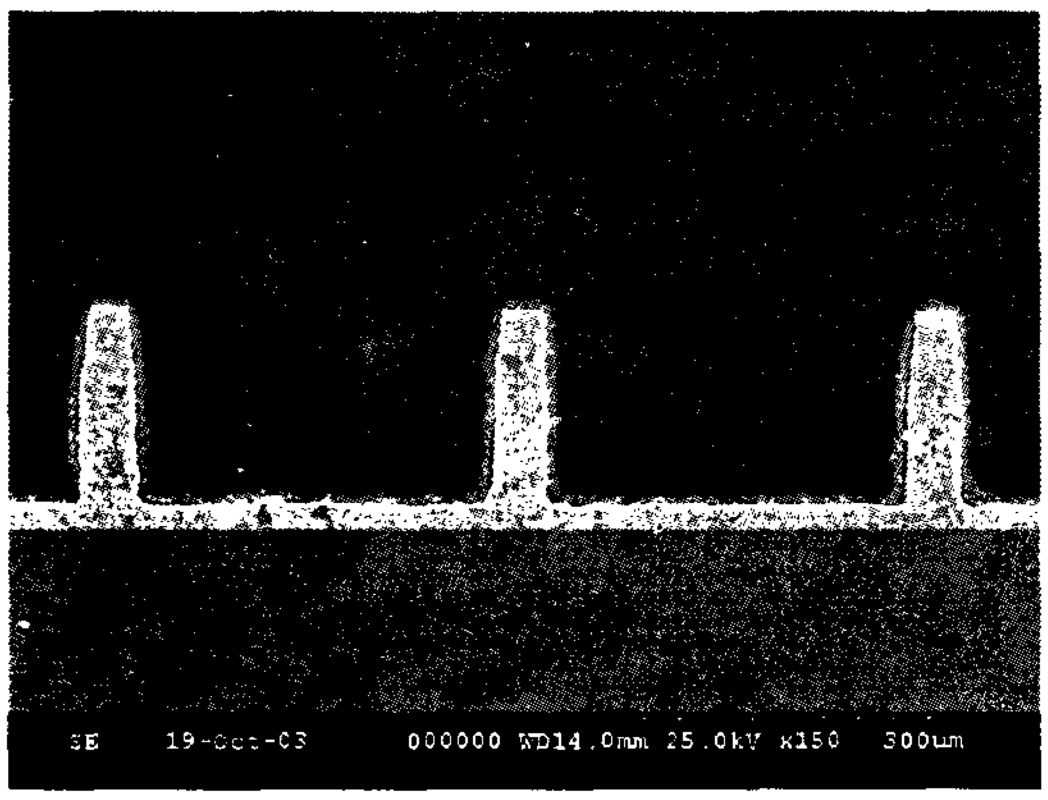
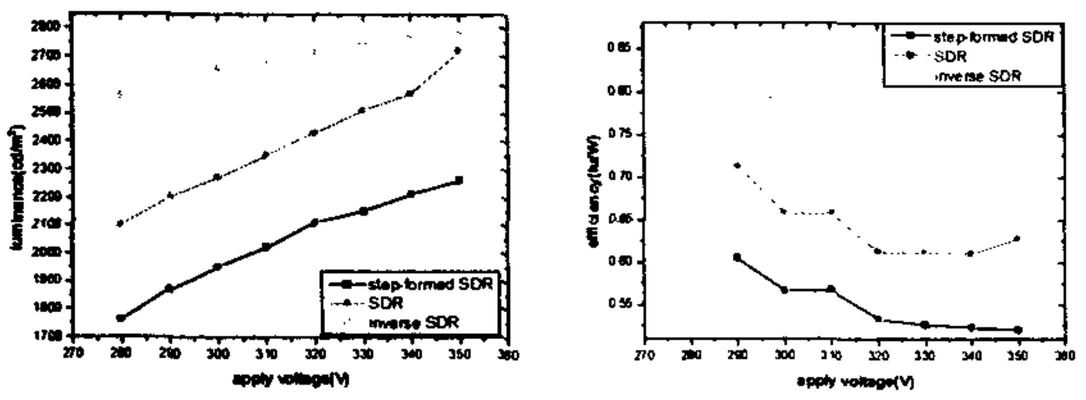


Fig. 3. Phosphor layer formed on waffle type barrier ribs via osmosis coating process.

Using those rear plates, luminance of the panels with SDR, inverse SDR and step-formed SDR cells were evaluated. As noted from Figure 4, the luminance and luminance efficiency of inverse SDR was highest, followed by regular SDR and step-formed SDR. In this case, the cell opening ratio was 80%. Higher luminance with the inverse SDR type discharge cells is believed to be cause by longer-gap discharge compared with regular SDR type discharge cells. The length of sustaining electrode of the inverse SDR is $203\mu m$ and that of regular SDR is $148\mu m$.

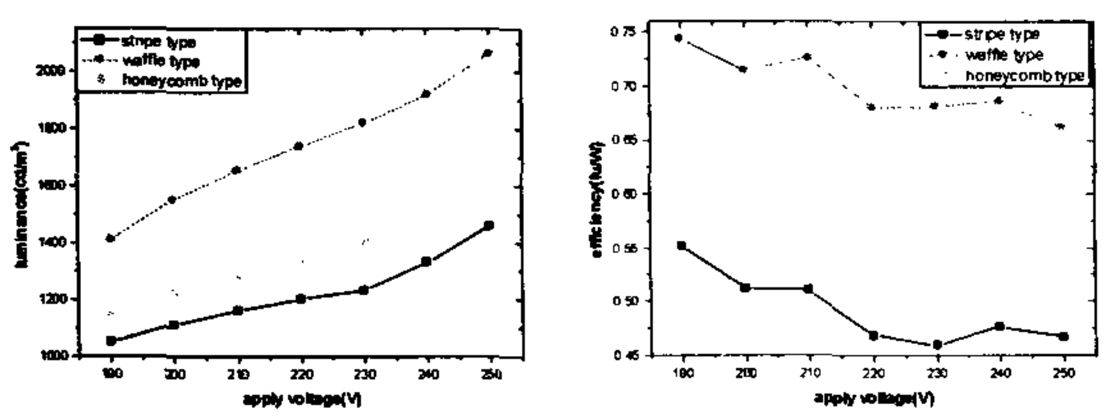
The low luminance of step-formed SDR compared with regular SDR seems to be caused by reduced area of phosphor coating as in Fig. 2(a). The luminance efficiency was highest with the inverse SDR, followed by regular SDR and step-formed SDR (Fig. 4(b)).



(a) (b)

Fig 4. Effect of SDR barrier rib types on luminance efficiency of panel.

The luminance and luminance efficiency of other types of barriers ribs including waffle, honeycomb, and stripe cells were measured (Figure 5). In order to examine the effect of discharge cell morphology, the cell opening ratio was maintained to 80% and the morphology of sustaining electrode to stripe type to each discharge cell type. As revealed in Fig. 5(a), the luminance of panel with waffle type discharge cells was highest followed by honeycomb and stripe type cells. When the cell opening ratio is the same for such cells, the surface area and discharge volume of waffle and honeycomb discharge cells were calculated to be similar to each other. Those values were reduced with the stripe type as shown in Figure 6. Thus, the highest luminance and luminance efficiency of waffle type discharge cell is mainly due to the discharge characteristics rather than the increased area for phosphor coating.



(a) (b)

Figure 5. Luminance (a) and luminance efficiency (b) of panel with waffle, honeycomb, and stripe type barrier ribs.

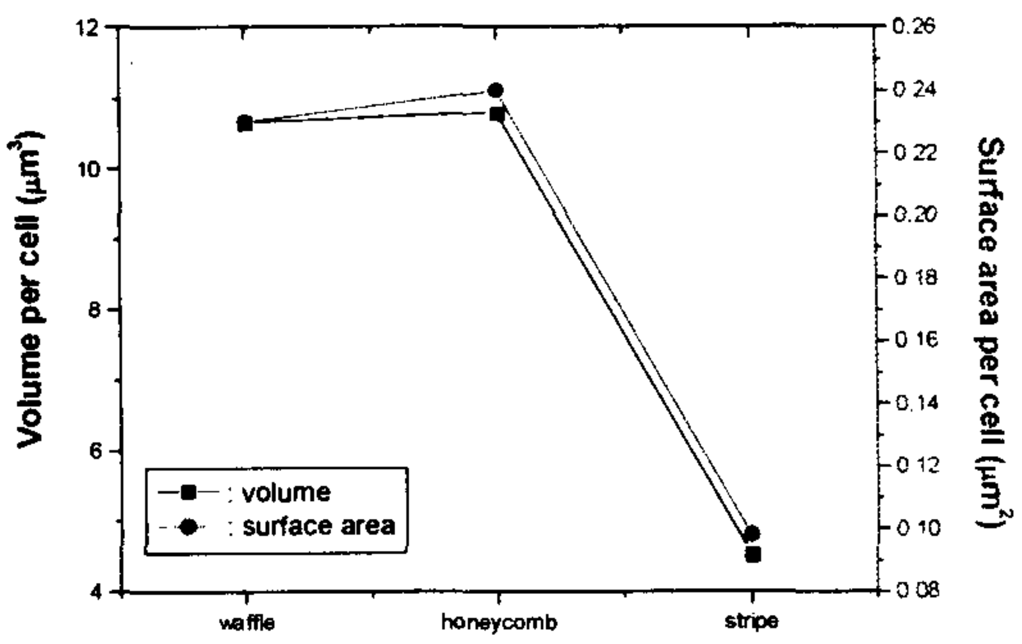


Figure 6. Specific area and volume of each discharge cells.

Since the luminance and luminance efficiency of the panels became enhanced with the increase in volume and surface area of discharge cells, rear plates with honeycomb type cells of different cell opening ratios ranging from 90 to 70% were prepared. As shown in the figure, the luminance of the panel was improved by 26% as the cell opening ratio was increased from 70% to 80%. Further increase of the opening ratio to 90%, however, resulted in decreased luminance.

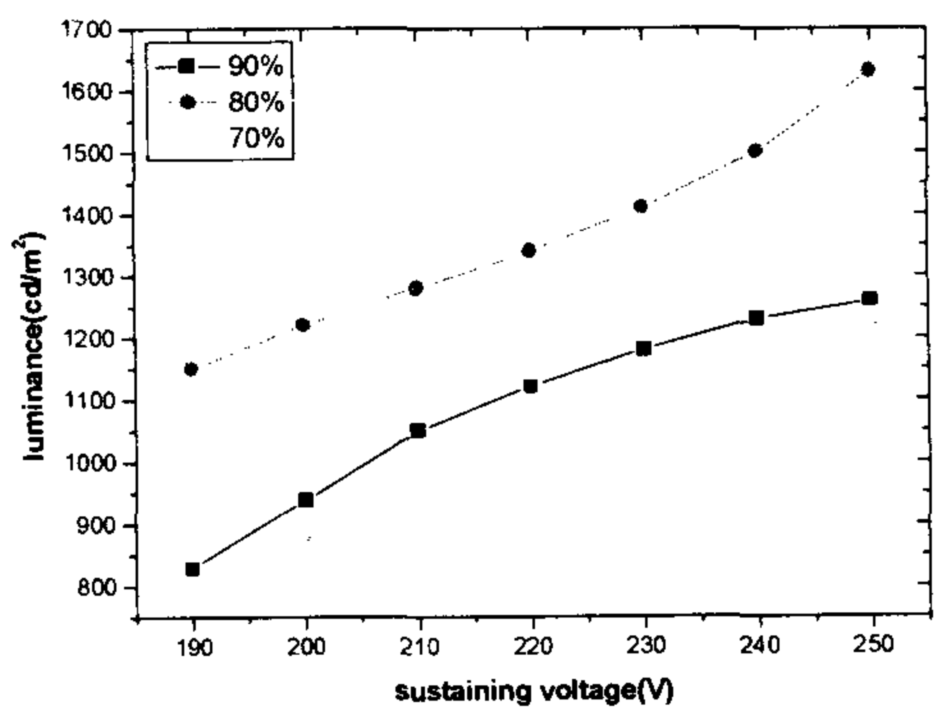
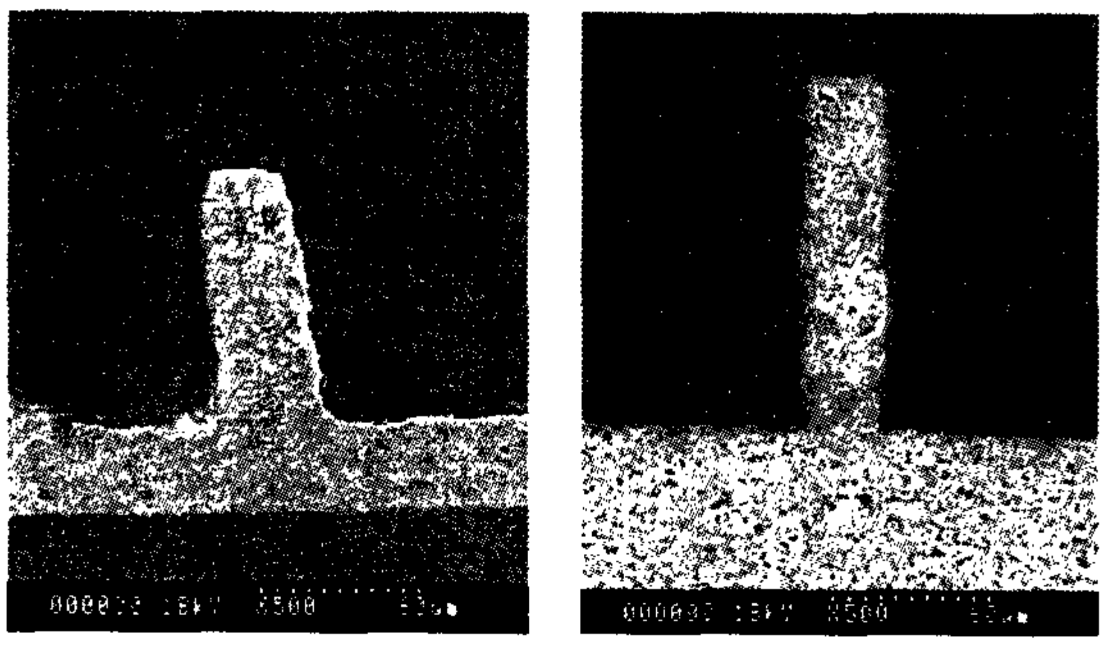


Figure 7. Effect of cell opening ratio on luminance of honeycomb type discharge cells.

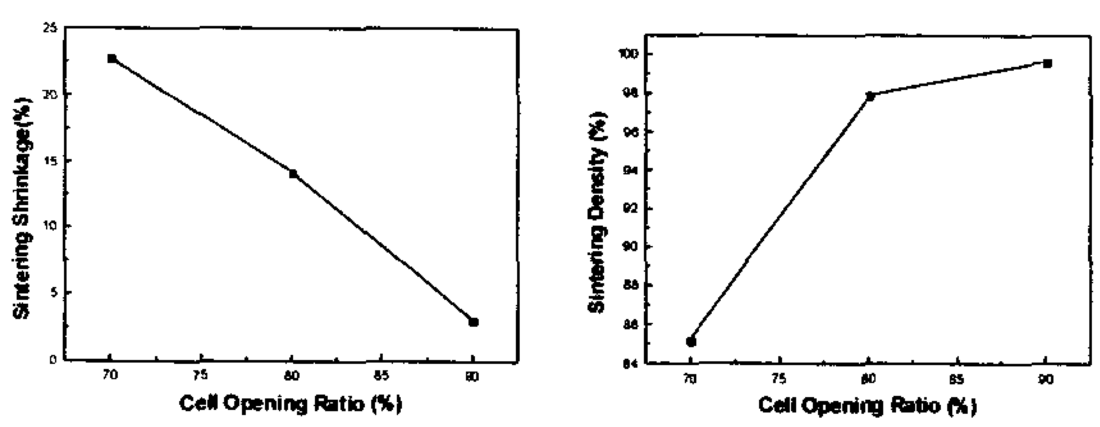
Detailed examination of the cells revealed that the cells with high cell opening ratios became slightly bent or slumped after the sintering as shown in Figure 8(a). This phenomenon may be caused either by the bending of the barrier ribs during mold removal or by slumping during sintering process.



(a) (b)

Figure 8. SEM micrograph of honeycomb type cells with cell opening ratio of 90%: (a) after sintering and (b) before sintering.

SEM micrograph of the barrier ribs prior to sintering, however, revealed that the ribs remained straight as shown in Fig. 8(b). Thus, the sintering shrinkage of barrier rib width was measured (Fig. 9). As noted from the figure, the sintering shrinkage decreased monotonically from 23 to 3% as the cell opening ratio is increased from 70 to 90% (Fig. 9(a)). This reduced shrinkage should result in either lack of sintering or slumping of barrier ribs. When the sintered density of the barrier ribs were measured (Fig. 9(b)), the density found to in crease with the cell opening ratio. When the cell opening ratio is 90%, 90%, the sintered density was closed to theoretical density of the barrier



(a) (b)

Figure 9. Sintering shrinkage of barrier rib width (a) and sintered density (b) as a function of cell opening ratio of discharge cell.

rib materials. This indicates that a significant degree of slumping occurs during sintering of barrier ribs of fine width. The width of barrier ribs when the cell opening ratio is 90% was about 20μm. The accelerated burn-out of organic constituents inside the thinner barrier ribs must have increased sinterability of the barrier ribs, eventually promoting the slumping.

4. Summary

The closed-cell type barrier ribs with phosphor layer coating were manufactured using capillary infiltration and osmosis coating process. It was demonstrated in this work that those process could provide a new way of manufacturing rear plates of PDP with high-definition closed-cell type barrier ribs. The cells with large discharge volume and phosphor coating area such as inverse SDR and waffle type barrier ribs were found to have high luminance and luminance efficiency.

5. Acknowledgements

This work has been supported by 21th century frontier R&D program of ministry of science and technology of Korea. Authors would like to appreciate the financial support of the program.

6. References

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